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NEST SITE CHARACTERISTICS OF THREE COEXISTING ACCIPITER HAWKS IN NORTHEASTERN OREGON

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Abstract

Habitat data were evaluated at 34 Goshawk (*Accipiter gentilis*), 31 Cooper's Hawk (*A. cooperii*), and 15 Sharp-shinned Hawk (*A. striatus*) nest sites in coniferous forests of northeastern Oregon. Crown volume profiles indicate a strong similarity in vegetative structure at nest sites of *cooperii* and *striatus*; both commonly nest in younger successional stands than *gentilis*. Habitat separation of nest sites among the three species was illustrated using a stepwise discriminant analysis; 88% of all *gentilis* sites were correctly classified. Interspecific overlap in nest site habitat was further demonstrated using a canonical analysis of habitat variables. Nest site habitat space of *gentilis* is distinct and is less variable in structure than that of the other species. *Cooperii* preferred nesting sites with northern aspects, whereas *striatus* and *gentilis* showed no preference. The use of mistletoe (*Arceuthobium* sp.) growth by *cooperii* for nest platforms (64% of all nests) may explain its preference for Douglas fir (*Pseudotsuga menziesii*) as a nesting tree. Douglas fir is most commonly parasitized by mistletoe.

Introduction

Populations of the Goshawk, Cooper's Hawk, and Sharp-shinned Hawk are sympatric in the coniferous forests of northeastern Oregon. These congeneric predators may coexist by partitioning the resources available to them, thus avoiding competition when resources are limited. It has been demonstrated that partitioning of food resources occurs among these three accipiters by the selection of prey which is optimal for the size and behavior of each species (Reynolds 1979). *Gentilis* takes larger prey and a greater proportion of mammals, while *striatus* takes primarily small song birds. Prey items of *cooperii* fall on the gradient between these two (Storer 1966, Snyder and Wiley 1976, Reynolds 1979). In this study our objective was to determine whether each species located its nest in a unique type of habitat. Previous *Accipiter* nest site studies were limited by the paucity of sites investigated (generally < 10 per species for a locality, usually considerably fewer). In this study, 80 nest sites were investigated in the coniferous forests of northeastern Oregon.

Several studies of avian species provide evidence that birds respond to vegetational features in selecting their habitats (Pitelka 1941, Sturman 1968, Wiens 1969, Reynolds et al. 1982).

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Vegetation height, amount at particular levels, density, and life form were found to be important factors affecting passerine diversity (MacArthur et al. 1962). Sturman (1968) found that the breeding densities of the Black-capped Chickadee (*Parus atricapillus*) were significantly correlated with canopy volume of trees and shrubs. The physiognomy and some aspects of the vegetative structure of North American *Accipiter* nest sites was described in Utah by Hennessy (1978) and in Oregon by Reynolds et al. (1982). Both authors found that differences in *Accipiter* nest sites were primarily related to vegetative structure immediately surrounding the nest site which reflected the successional stage of the forest stand. Newton et al. (1977) found that the European Sparrowhawk (*Accipiter nisus*) nested only in woodlands of a certain vegetational structure equated with the growth stage. They also suggested that availability of nesting habitat along with spacing of nesting territories, which was a function of prey availability, limited overall densities of nesting territories.

Multivariate techniques were useful for analysis of the vegetative structure of habitat and description of the n-dimensional species niche (Green 1971). Several authors have used these methods to describe habitat selected and niche separation by analysis of vegetative structure associated with each species within the community (James 1971, Anderson and Shugart 1974, Cody 1978, Holmes et al. 1979, Reynolds et al. 1982). Multivariate techniques used in this study were chosen because of their power in describing multi-dimensional habitat spaces. N-space habitat vectors can easily be reduced to fewer dimensions by linear combinations of the original variables.

Methods

Study Area

The study area was located within and around the Wallowa-Whitman National Forest in northeastern Oregon between 45° and 46° North Latitude at elevations between 500 and 1600 m. The Wallowa-Whitman Forest, in the Blue Mountains province of Oregon, consists primarily of montane forest with moderate to steep relief. A detailed description of the physiognomy of this province and climatic conditions of various forest types are given by Franklin and Dyrness (1973). Hall (1973) recognized several climax forest plant communities in this area: ponderosa pine (*Pinus ponderosa*), lodgepole pine (*P. contorta*), grand fir (*Abies grandis*), subalpine fir (*A. lasiocarpa*), and mixed conifer stands, e.g., ponderosa pine, Douglas fir, grand fir, and western larch (*Larix occidentalis*). Many stands are on a gradient between these communities. Vegetation of natural open areas consists of grass and forbs. A mosaic of forest stands of various age class and species composition is present.

Since searches for the three species were conducted, all habitat types within the forests were checked. Nest searches were concentrated in areas where repeated sightings or trapping of *Accipiters* occurred. Information provided by U.S. Forest Service personnel and loggers often led to nest discoveries.

Vegetative Sampling

Occupied and unoccupied nests at undisturbed sites which had been located between 1975 and 1979 were examined. Unoccupied nests were generally sampled the year following occupancy, but in a few cases 2 years intervened before measurement. This delay resulted from habitat data not being recorded during the first 2 years of the nesting study. Each nest site was examined only once; nesting adults were captured and banded when possible. If a known pair (i.e., both previously banded and recaptured) was located during more than 1 year, only the first nest site was used in this analysis. Vegetation was sampled within 0.08 ha circular plots (16.03 m radius) centered on the nest tree. Vertical distribution of tree crown volume was measured using the technique of Mawson et al. (1976) with the program HTVOL. Each tree within the plot was considered in relation to 15 possible crown shapes and relegated to the best fit. Dimensions of these shapes were measured using a clinometer and steel tape. The program HTVOL calculated total crown volume within 3 m height classes up to 36 m to develop a crown profile for each plot. Diameter at breast height (dbh) and species were recorded for each tree in the plot. All plants greater than 0.3 m and less than or equal to 3 m in height were measured as shrubs. Shrub crown volume was calculated by fitting shrubs or

groups of shrubs into the smallest possible cube and measuring the dimensions of that cube. Shrub and tree crown volumes were combined to develop a total crown profile for each plot, since shrub crown volumes contribute to the vertical structure of the site. Ground cover was measured by point sampling along transects in four cardinal directions from the nest tree (James and Shugart 1970). Slope and aspect of each site were recorded.

The following nest tree characteristics were recorded: species, condition (alive, dead), dbh, height, and crown height. The following nest characteristics were measured: height, exposure, nest substrate and canopy coverage at the nest (measured with a spherical densiometer).

Analysis

Tree crown profiles and stand composition variables were tested for differences among *Accipiter* species using multivariate analysis of variance (MANOVA). Orthogonal multiple comparisons were used to identify significantly different variables (Morrison 1967). Stepwise discriminant analysis was used to select those variables which were most important in discriminating among nest sites of the species. A canonical analysis of nest site variables was used to identify variables which were the most powerful discriminators of each species' nesting habitat.

Univariate data were tested with one-way analysis of variance and Chi-square tests (Snedecor and Cochran 1967). Nest tree selection was examined using Bonferroni normal statistics in conjunction with Chi-square (Neu et al. 1974). Nest site aspect and nest directional exposure were tested for significant mean direction with Rayleigh's R statistics (Zar 1974). Computer analyses utilized the Statistical Analysis System (SAS) (Helwig and Council 1979) and the Statistical Package for the Social Sciences (SPSS) (Nie et al. 1975).

Results

Nest Site Habitat Structure

Crown volume was calculated for the plots surrounding 34 *gentilis* nests, 31 *cooperii* nests and 15 *striatus* nests to yield mean crown profiles of the nest stands of each species (Fig. 1). Crown profiles indicate a strong similarity in vegetative structure of *cooperii* and *striatus* nest sites. Both commonly nest in younger successional stands with highest density of foliage in layers from 3 to 15 m. Nests of *gentilis* are found in older growth coniferous stands at the opposite end of the successional spectrum. Crown volumes at lower levels, 0 to 12 m, are generally low while the majority of foliage is in strata from 12 to 24 m. This profile is produced by stands of larger coniferous trees (≥ 16.5 cm dbh), with relatively low understory crown volumes.

MANOVA of crown profiles of the three species indicates a significant difference among species of strata from 0 to 36 m ($P < 0.05$). This significance results from lower crown volumes in the sites of *gentilis* from 6 to 12 m and larger crown volumes in the 18 to 24 m strata when compared to these strata of *cooperii* and *striatus* nest sites. No significant difference between crown profiles of *cooperii* and *striatus* were detected.

Frequency of various dbh classes, number of trees per 0.08-ha, basal area of the plot, and mean tree dbh (Table 1) provide further information on the vegetative structure of nest sites. Trees less than 16.5 cm dbh made up 77% and 80% of the total tree density of *cooperii* and *striatus* sites respectively, while only 51% of the total tree density of *gentilis* sites. Nests of *gentilis* were located on sites with fewer and larger trees than those of *cooperii* and *striatus*. The tree dbh classes, basal area, and mean dbh were used in a MANOVA to test for differences among species. Tree density was omitted since the sum of size class frequencies equal the total tree density, reducing the rank of the model. No significant differences were detected between *cooperii* and *striatus*, but *gentilis* sites were significantly different ($P < 0.05$) in frequency of the two smallest dbh size classes and average dbh.

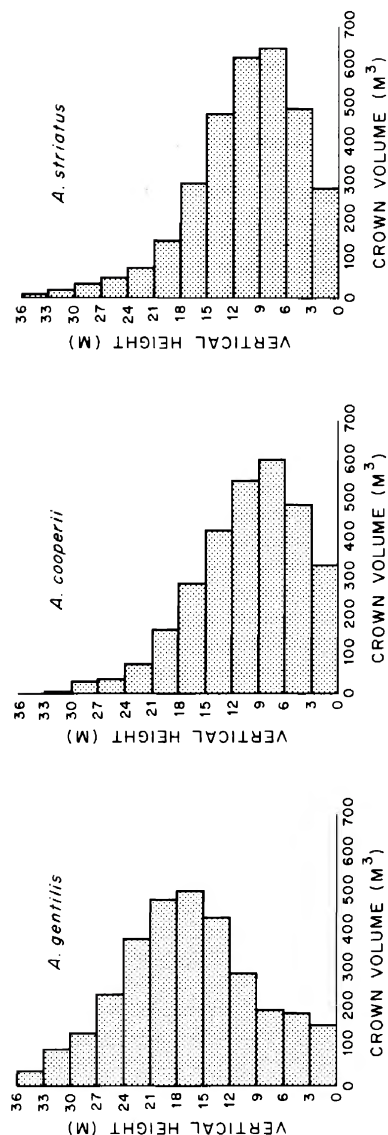


Figure 1. Crown profiles for the plots surrounding the nest sites of three species of *Accipiter* using mean crown volumes for each stratum.

Table 1. Structural characteristics of plots surrounding nest sites

Variable	<i>A. gentilis</i> (N = 34)		<i>A. cooperii</i> (N = 31)		<i>A. striatus</i> (N = 15)	
	Mean frequency	S.D.	Mean frequency	S.D.	Mean frequency	S.D.
Tree size dbh						
2.5-8.9 cm	22.4*	19.8	74.7	69.9	92.5	73.6
8.9-16.5 cm	19.0*	12.6	38.2	21.9	56.6	42.4
16.5-31.7 cm	23.4	13.3	24.7	12.1	30.1	11.9
31.7-41.9 cm	10.8	6.2	6.8	4.3	5.8	4.9
> 42 cm	5.9	4.5	2.8	3.6	2.3	2.4
Stems/0.081 ha	81.6	34.2	146.0	86.7	187.3	117.8
Basal area (m ²) (0.081 ha)	4.2	1.4	3.2	1.4	3.5	1.2
Mean dbh (cm)	22.1*	5.8	15.0	5.6	12.9	3.0
Slope (%)	14.0	10.6	17.2	10.3	24.6	18.8
Ground cover						
forbs (%)	46.7	18.2	25.3	16.3	29.5	13.5
Ground cover						
grasses (%)	12.6	11.1	16.9	12.9	10.1	7.7
Ground cover						
absent (%)	40.4	20.5	56.5	18.7	59.8	16.1

* (P < 0.05).

Nest site habitat separation among the three species can be illustrated using the crown volume variables, tree dbh classes, basal area, and mean dbh variables in a stepwise discriminant analysis. The discriminant functions also provide a means of classifying each observation according to *a posteriori* probabilities that an observation classified as one particular habitat is in fact occupied by that species. The classification results given in Table 2 show that 88% of all *gentilis* sites were correctly classified. Sites of *cooperii* and *striatus* were misclassified most often by the lack of discriminating power between these two species rather than similarities with *gentilis* sites.

Interspecific overlap in nest site habitat can be graphically demonstrated using a canonical analysis of habitat variables in the same manner as Cody (1978). Canonical analysis generates new variables which are linear combinations of original variables, each weighted according to their power to discriminate. The position of individual observations can be plotted along the canonical functions to get a graphical interpretation of the nature and extent of species separation. Nest site habitat space of *gentilis* is distinct from the other two species and appears to be less variable in structure (Fig. 2).

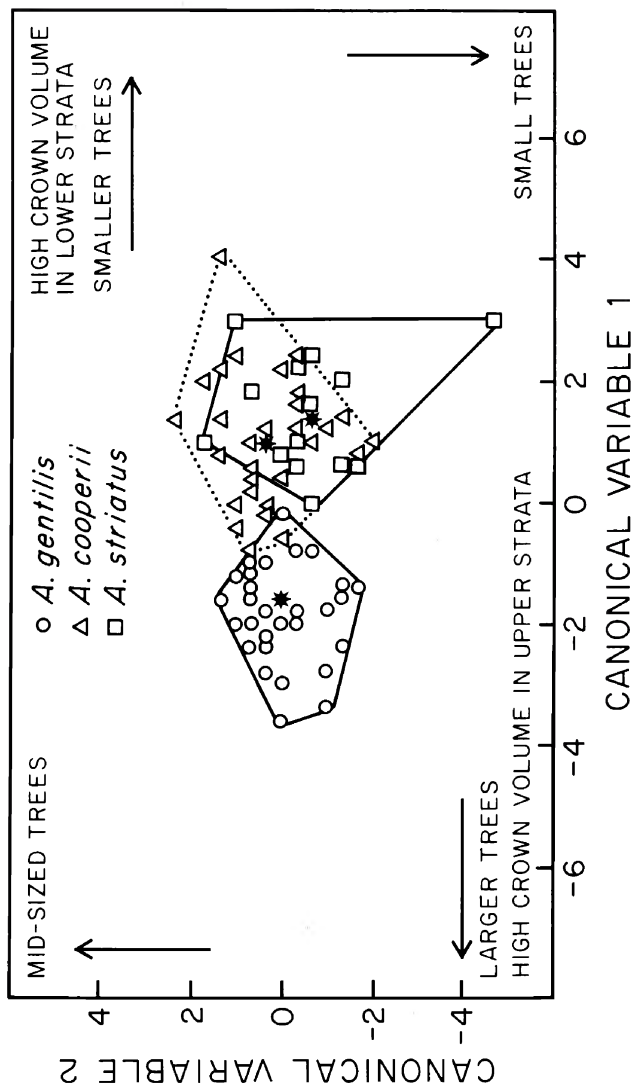


Figure 2. Distributions of nest site habitat for three species of *Accipiters*. Axes represent canonical variables from canonical analysis of original nest site variables (star represents group means).

Table 2. Classification results of discriminant analysis of nest site characteristics

Group	N	Predicted group membership		
		<i>A. gentilis</i>	<i>A. cooperii</i>	<i>A. striatus</i>
<i>A. gentilis</i>	34	30 88.2%	3 8.8%	1 2.9%
<i>A. cooperii</i>	31	2 6.5%	19 61.3%	10 32.3%
<i>A. striatus</i>	15	0 0.0%	7 46.7%	8 53.3%

[71% of grouped cases were correctly classified]

Nest Site Aspect

The nest site aspect (assuming equal availability) was tested for significant mean directional preference (Fig. 3). Nests on flat terrain (< 3% slope) were excluded. *Gentilis* nest sites showed a mean angle of 24° (0° = north) with an angular deviation of $\pm 87^\circ$. However, no preference of site aspect was indicated ($P < 0.20$). *Gentilis* also showed greater variability in the predominant tree species at the nest sites and a greater frequency of nests on flat terrain.

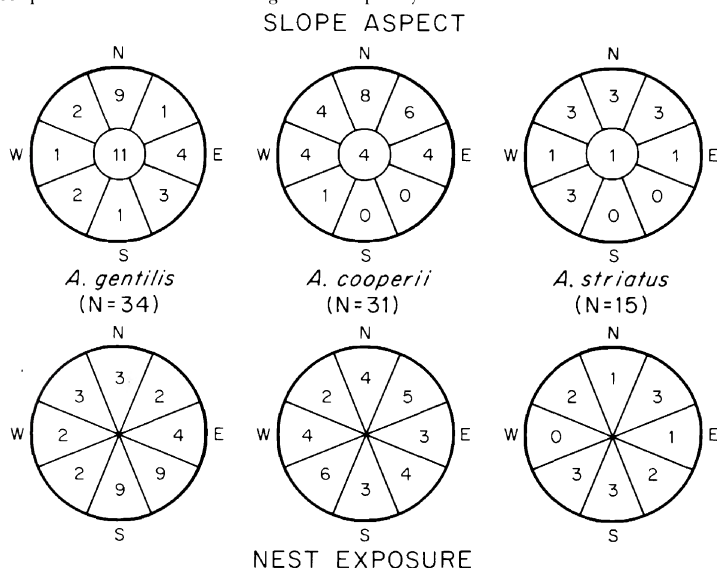


Figure 3. Nest site aspects and nest exposures relative to the bole of the nest for each species. Number in each cell is the frequency of sites on that aspect or nests with that exposure.

The nest sites of *cooperii* showed a significant preference for northern ($3^\circ \pm 64^\circ$) aspects ($P < 0.001$). No directional preference ($338^\circ \pm 78^\circ$) was indicated for *striatus* ($P < 0.20$), although 60% of nest sites were on northern aspects.

Nest Tree Characteristics

To evaluate the tree species preferred by each of the accipiters for nesting, we first pooled the number of trees of adequate size (*gentilis* 20-76 cm dbh, *cooperii* 18-76 cm dbh, *striatus* 10-50 cm dbh) within the plots for each *Accipiters* species. The proportion of each tree species is shown in Figure 4. Grand fir and Douglas fir were the predominant tree species at most nest sites for all three accipiters. Nest tree selection was examined by comparing the proportion of each tree species available with the proportion used as a nest tree. None of the accipiters nested in tree species in proportion to their availability (*gentilis* $P < 0.005$, *cooperii* $P < 0.005$, *striatus* $P < 0.01$). *Gentilis* showed preference for Douglas fir and western larch, while *cooperii* showed a preference for Douglas fir. Lodgepole pine was avoided by all species.

Selection of avoidance of a tree species for nesting is probably due to growth form and foliage patterns unique to each tree species. Structural characteristics of nest trees are given in Table 3. A negative value for the nest-crown relationship represents nests below the canopy. Nest heights of *striatus* were significantly lower than those for the other two species. Nest-crown relationship was significantly different only between *gentilis* and the other two species. A correlation was indicated between nest height and the nest-crown relationship ($R^2 = 0.53$, $N = 80$, $P < 0.0001$). Position of the nest in the nest tree may be strongly affected by the height of the nest tree canopy. *Gentilis* prefers to build below the crown in more exposed positions, while the other two species build up in the canopy.

Significant differences were found in canopy coverage over the nest for all three species ($P < 0.0001$) using ANOVA on arcsine-converted-percentage-data (Table 3). *Gentilis* nested in

Table 3. Nest tree characteristics of three species of *Accipiters*

Variable	<i>A. gentilis</i> (N = 34)		<i>A. cooperii</i> (N = 31)		<i>A. striatus</i> (N = 15)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Dbh (cm)	51.6*	14.9	43.7	15.2	28.7	13.7
Nest height (m)	14.5	4.4	12.1	3.2	7.6*	3.2
Nest-crown relationship (m)	-1.7*	4.8	2.0	4.0	1.0	3.9
Nest canopy coverage (%)	88.1**	8.8	95.2	4.1	97.9	1.5
Frequency of use of mistletoe for nest substrate	14.7%		64.5%		20.0%	
Frequency of use of dead trees for nest trees	17.6%		0		0	

* ($P < 0.05$).

** ($P < 0.0001$).

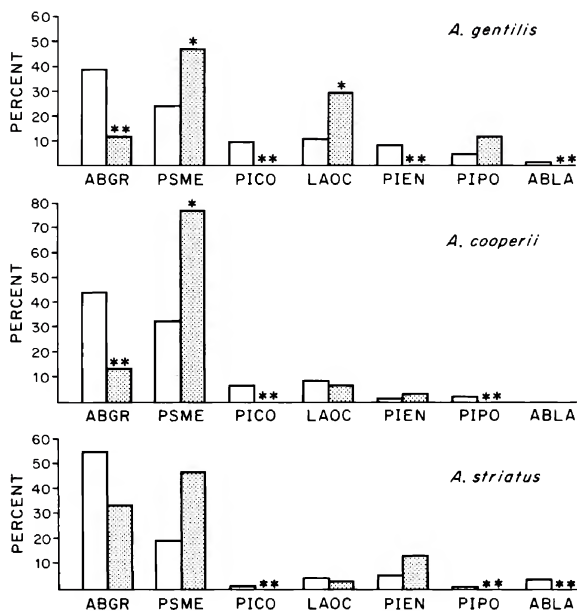


Figure 4. Stand composition and nest tree selection for three species of *Accipiter*. Open bars represent proportions of each tree species from the pooled species composition of nest sites. Shaded bars represent the proportion of each tree species used as nest trees. ** = significant avoidance using 90% confidence intervals; * significant selection; no asterisk indicates proportional use. (ABGR = grand fir, PSME = Douglas fir, PICO = lodgepole pine, LAOC = western larch, PIEN = Englemann spruce [*Picea engelmannii*], PIPO = ponderosa pine, ABLA = subalpine fir).

larger trees at a greater height, but below the canopy of the nest tree and with less canopy coverage over the nest. The higher degree of exposure and the greater accessibility to *gentilis* nests was further illustrated by the use of dead trees for nesting (Table 3). Dead trees supporting occupied nests ranged from those still retaining needles to snags. Accipiters often use masses of mistletoe-affected growth as a nest substrate (Table 3). These tangles of foliage provide a sturdy and well-concealed nest substrate most often used by *cooperii* (64% of all nests). This preference may explain selection for Douglas fir as a nest tree since this tree is most commonly parasitized by mistletoe.

Nest exposure, in relation to tree bole, was examined to determine whether preferences existed for nest placement (Fig. 3). *Gentilis* preferred the southeast side of the tree (mean $148^{\circ} \pm 83^{\circ}$) for nest placement ($P < 0.02$). Both *cooperii* and *striatus* showed a random distribution of nest placement (*cooperii*, $P = 0.60$; *striatus*, $P = 0.60$). Concealment of nests and shading from sunlight may be more important for those two species than insolation effects. Distance from

the nest tree to a permanent water source was significantly farther for *cooperii* ($473 \text{ m} \pm 545$) than for *gentilis* ($199 \text{ m} \pm 239$) or *striatus* ($200 \text{ m} \pm 242$) ($P < 0.02$).

Discussion

The importance of the vegetative structure at accipiter nest sites, as pointed out by several authors (Hennessy 1978, Reynolds et al, 1982), is confirmed by this study. The critical characteristics for nest sites of each species are structural features associated with the successional stage of nesting stands. Intraspecific similarities in structural features of nest sites indicate that some species-specific selection of nesting sites occurs on the basis of vegetative structure.

Perceptual responses to complex habitats by birds are not well known but habitat selection is probably not based on any single environmental cue. Selection may be released by gestalt perception of the environment rather than by a few proximate factors (Lack 1933). James (1971) felt that each species had a characteristic perception of vegetational requirements of its habitat, the niche-gestalt. This was supported by consistent occurrence of a species when certain structural features of the vegetation were present as we found.

The association with certain structural characteristics is apparent even when comparing nest sites of accipiters occurring in other regions. Titus and Mosher (1981) examined *cooperii* nests in the eastern deciduous forests. Vegetative structure there was similar to what we found. Nest heights and nest tree size were also similar. Nest sites of *gentilis* in the Adirondack Mountains of New York also appeared similar in structure to our findings, i.e., Allen (1978) reported nest sites with most of the basal area in larger size classes of trees.

While all three species seem to occupy a single macrohabitat, the vegetative structure associated with each successional stage creates one type of patchiness within the heterogeneous macrohabitat. Differential use of these patches occurs in selection of nest sites. Nests of congeners were sometimes found in close proximity to each other; thus, interspecific spacing of nest sites did not seem to occur. Nest site availability was not determined, but this factor would affect the role that competition plays in nest site selection. Possible interspecific competition for nest sites was observed once; the replacement of a *cooperii* pair by a *gentilis* pair at the same nest site the following year.

Conceivably *gentilis* could exclude the other two species through social dominance or predation; however, evidence indicates that the presence of *gentilis* may not be a factor in excluding *cooperii* and *striatus* from using older age stands for nest sites. Reynolds (1979) indicated that in northwest Oregon, where *gentilis* was not found, *cooperii* and *striatus* did not fully utilize the available sites with vegetative structure similar to those preferred by *gentilis*. The similarity of nest sites of these two species was still evident even in the absence of *gentilis*.

Sites chosen by *cooperii* and *striatus* may provide concealment from avian predators such as the Great Horned Owl (*Bubo virginianus*) or *gentilis*. Use of mistletoe growth for nest sites and placement of nests within the canopy support this idea. *Gentilis* may be able to protect the nest more easily from large avian predators because of its size. However, predation of nests of all three accipiters by Great Horned Owls was recorded.

Thermoregulation may also play a role in nest site selection. Considering placement of nests, those of *gentilis* probably received higher insolation, at least during the early hours of the day. This population generally begins incubation in April with brooding in May. Higher insolation of nests may help mitigate the effects of low temperatures during this period. Canopy coverage directly overhead (88%) would still provide shading during periods of higher temperatures. Nest placement for *striatus* and *cooperii* showed no preference for exposure. Both species had nests in strata with high crown volumes and higher mean canopy

coverage. Thus, nest insolation may not be as important as nest concealment or shading during warm temperatures. Both species are migratory in our study area (unpublished band recovery data), and both begin incubation later than *gentilis*.

Nest site selection and nest placement may also be influenced by accessibility. An association between increasing body size and changes in the vegetative structure of nesting habitat is apparent. Spacing of stems and foliage at *gentilis* nest sites provide more open flight lanes. This factor may be important for adults as well as fledglings with inferior flight control. Several factors appear to be operating in the selection of nesting habitat including predation, morphological and physiological adaptations, prey availability (not assessed in this study), and to a lesser extent, social interaction with congeners.

A relatively recent factor which may have influenced the partitioning of nesting habitat, by limiting numbers of nest sites, is logging by man. Effects of logging are difficult to quantify, as reoccupancy of nest sites is not guaranteed even at undisturbed sites. If other suitable sites were available, logging may only cause a relocation of nest sites. However, if nesting sites are limited, logging could result in local reduction in the breeding population. The influence of logging may be especially critical for *gentilis* which is dependent upon older age stands. Logging may benefit populations of other avian predators such as the Red-tailed Hawk (*Buteo jamaicensis*) and Great Horned Owl (Franz 1977). Increased competition and predation upon accipiters could result. Logging may also alter the availability or vulnerability of certain prey species.

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Literature Cited

- Allen, B.A. 1978. Nesting ecology of the Goshawk in the Adirondacks. M.S. Thesis. State University of New York, Syracuse.
- Anderson, S.H. and H.H. Shugart. 1974. Habitat selection of breeding birds in an east Tennessee deciduous forest. *Ecology* 55:828-837.
- Cody, M.L. 1978. Habitat selection and interspecific territoriality among the sylvid warblers of England and Sweden. *Ecol. Monogr.* 48:351-396.
- Franklin, J.R. and C.T. Dyrness. 1973. Natural vegetation of Oregon and Washington. USDA For. Serv. Gen. Tech. Rep. PNW-8.
- Franz, K.E. 1977. Bird population changes after timber harvesting of a mixed conifer forest in Arizona. USDA For. Serv. Res. Paper RM-184.
- Green, R.H. 1971. A multivariate statistical approach to the Hutchinsonian niche: bivalve molluscs of central Canada. *Ecology* 52:543-556.
- Hall, F.C. 1973. Plant communities of the Blue Mountains in eastern Oregon and southeastern Washington. USDA For. Serv. R6 Area Guide 3-1.

- Helwig, E.S. and K.A. Council, Eds. 1979. SAS users guide, 1979 edition. SAS Inst. Inc., Raleigh, North Carolina.
- Hennessy, S.P. 1978. Ecological relationships of Accipiters in northern Utah with special emphasis on the effects of human disturbance. M.S. thesis. Utah State University, Logan.
- Holmes, R.T., R.E. Bonney and S.W. Pacala. 1979. Guild structure of the Hubbard Brook bird community: a multivariate approach. *Ecology* 60:512-520.
- James, F.C. 1971. Ordination of habitat relationships among breeding birds. *Wilson Bull.* 83:215-236.
- James, F.C. and H.H. Shugart. 1970. A quantitative method of habitat description. *Audubon Field Notes* 24:727-736.
- Lack, D. 1933. Habitat selection in birds. *J. Anim. Ecol.* 2:239-262.
- MacArthur, R.H., J.W. McArthur and J. Preer. 1962. On bird species diversity. *Am. Nat.* 96:167-174.
- Mawson, J.C., J.W. Thomas and R.M. DeGraff. 1976. Program HTVOL the determination of tree crown volume by layers. USDA For. Serv. Res. Paper NE-354.
- Morrison, D.G. 1967. Multivariate statistical methods. McGraw-Hill Book Co., New York.
- Neu, C.W., C.R. Byers and J.M. Peek. 1974. A technique for analysis of utilization-availability data. *J. Wildl. Manage.* 38:541-545.
- Newton, I., M. Marquiss, D.N. Weir and D. Moss. 1977. Spacing of Sparrowhawk nesting territories. *J. Anim. Ecol.* 46:425-441.
- Nie, N., C.H. Hull, J. Jenkins, K. Steinbrenner and D.H. Bent. 1975. Statistical package for the social sciences. McGraw-Hill Book Co., New York.
- Pitelka, F.A. 1941. Distribution of birds in relation to major biotic communities. *Am. Midl. Nat.* 25:113-137.
- Reynolds, R.T. 1979. Food and habitat partitioning in the groups of co-existing *Accipiter*. Ph.D. dissertation. Oregon State University, Corvallis.
- Reynolds, R.T., E.C. Meslow and H.M. Wight. 1982. Nesting habitat of coexisting *Accipiter* in Oregon. *J. Wildl. Manage.* 46:124-138.
- Snedecor, G.W. and W.G. Cochran. 1967. Statistical methods. Iowa State University Press, Ames.
- Snyder, N.F.R. and J.W. Wiley. 1976. Sexual size dimorphism in hawks and owls of North America. *Ornithol. Monogr.* 20:1-96.
- Storer, R.W. 1966. Sexual dimorphism and food habits in three North American *Accipiters*. *Auk* 83:423-436.
- Sturman, W.A. 1968. Description and analysis of breeding habits of the chickadees, *Parus atricapillus* and *P. rufescens*. *Ecology* 49:418-431.
- Titus, K. and J.A. Mosher. 1981. Nest-site habitat selected by woodland hawks in the central Appalachians. *Auk* 98:270-281.
- Wiens, J.A. 1969. An approach to the study of ecological relationships among grassland birds. *Ornithol. Monogr.* 8:1-93.
- Zar, J.H. 1974. Biostatistical analysis. Prentice-Hall, Englewood Cliff, New Jersey.

BALD EAGLE NEST WATCHERS NEEDED

The U.S. forest Service needs volunteers for observation of nesting Bald Eagles in Central Arizona, February through May 1984. Duties involve collection of behavioral and habitat data and protection of nest sites. Back country travel and camping are required. Subsistence living quarters and reimbursement for field expenses are provided. Field experience is desirable. Anyone interested should contact Larry Forbis, Tonto National Forest, Box 29070, Phoenix, Arizona 85038 (602 261-4240), or Terry Grubb, Rocky Mountain Forest & Range Experiment Station, ASU Campus, Tempe, Arizona 85287 (602 261-4365).

GROWTH OF BODY COMPONENTS IN PARENT-AND HAND-REARED CAPTIVE KESTRELS

by

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Abstract

Twelve female and 13 male American Kestrels (*Falco sparverius*) were hand-reared and fed to satiation 4 times daily. The growth of the tarsus, third toe, manus, antebrachium, bill, and skull, as well as body weight, were measured every 6 days up to fledging and compared to identical measurements recorded from 8 female and 11 male kestrels raised naturally by captive parents provided a similar but *ad libitum* diet. Parent-raised birds grew more rapidly and achieved greater body size than hand-reared birds. Males grew faster than females for most parameters, particularly toe and tarsus length.

Introduction

With the advent of captive breeding programs for falcons, both for laboratory research (Bird and Rehder 1981, Bird 1982) and release into the wild (Newton 1979), the demand for information on the nutritional health of captive-raised falcons is increasing.

Ricklefs (1968) felt that nutritional deficiencies may affect growth rates of wild birds and advised that only growth data collected under favourable conditions be used for comparative purposes. Furthermore, he suggested that hand-rearing techniques could prove to be valuable in this regard. Olendorff (1974) pursued this suggestion in a laboratory investigation of 3 *buteo* species, but has not provided comparative growth data for birds raised naturally by their wild parents.

We had the opportunity to compare patterns of growth of body components of captive American Kestrels (*Falco sparverius*) raised by parent birds with those hand-reared by humans. The major source of variability between the two groups was food availability, i.e., hand-reared birds were fed to satiation 4 times daily, and parent-raised birds had *ad libitum* food supply. Thus, our objectives were: 1) to describe growth of selected body components in the kestrel and to contrast these patterns with those of other raptorial species; 2) to assess the effect of food availability as a result of hand-rearing on growth patterns; and 3) to compare the growth rates of male and female kestrels.

Materials and Methods

All kestrels were offspring bred from stock at the Macdonald Raptor Research Centre of McGill University in Ste. Anne de Bellevue, Quebec. Eight females and 11 males raised by parents from naturally-incubated eggs were randomly

selected for measuring from nestboxes in 6 and 8 breeding pens respectively, comprising a total of 9 different broods. Twenty-five (12 females and 13 males) were randomly selected from offspring being hand-reared from artificially-incubated first clutches. Pens and management practices have been described elsewhere (Bird *et al.* 1976).

Hand-rearing techniques were as follows. After day 1 in the hatcher maintained at 36.5°C, chicks were moved to a styrofoam chest which was thermostatically heated by electrical heating tape or poultry heating elements. A tray of distilled water covered by wire mesh was kept on the brooder floor. The chicks were kept in wire corrals or in soup bowls, each bird identified by non-toxic felt marker pens. The brooder temperature was initially set at 35°C and was decreased every few days until room temperature was reached at 2 weeks. When pinfeathers showed, the chicks were transferred to a plastic swimming pool lined with wood shavings. They eventually fledged into a room 6.6 x 6.6 x 2.5 m with a floor of sand and wooden perches.

Between 18 and 24 hrs after hatching, the chicks were fed small pieces of neonatal mice by blunt forceps. This continued 4 times per day approximately every 4 hours beginning at 0830 hrs, each time to the point of satiation. After about 10 days, they were fed day-old cockerels and, occasionally, laboratory mice. During this period, cockerels without down, beaks and legs, or mice without skin and tails were mashed in a Waring blender with vitamin and calcium supplements added daily. When the young were able to feed themselves, at approximately 14 days, the cockerels or mice were blended whole to provide roughage. As the kestrels approached fledging age at about 25 days, the food was mashed less until whole unmashed cockerels were provided.

The kestrels raised by their parents relied completely on their parental food supply: day-old cockerels and laboratory mice dipped in bonemal and/or vitamin supplements provided *ad libitum*. Food consumption was not recorded for either hand-reared or parent-raised birds. Rather, the major difference in feeding regimes was food availability: continuous parental attention to begging young versus hand-feeding 4 times per day maximum.

Linear measurements were taken on the left side of the body with a Vernier caliper accurate to 0.1 mm. The following measurements were taken (see Olendorf 1972): 1) tarsal length, 2) antebrachial length, 3) bill depth, 4) skull width, and 5) bill length.

The last 3 measurements were taken as follows: 6) third toe length — the distance from the joint between the distal end of the tarso-metatarsus and the basal phalanx of the third toe, to the distal joint before the point where the talon emerges from the toe. (We decided not to force open the entire toe, including the casing around the talon, to prevent any damage to the foot bones. Therefore, the last section of the toe encasing the talon was omitted from the overall toe length.) 7) manus length — the distance between the wrist and the tip of the third phalanx approximated by the base of the primary feathers growing from the manus. 8) body weight — weight recorded to 0.1 g on a top-loader balance.

The first measurements were taken within 24 hr of hatching and subsequently every 6 days until fledging. Birds undergoing measuring generally had empty crops. The means and standard errors of the 8 body components were calculated 1, 7, 13, 19, 25 and 31 days post-hatching for parent- (PR) and hand-reared (HR), male and female kestrels. Mean body sizes of PR and HR kestrels were compared, sexes separately, within 24 hours post-hatching using the Mann-Whitney U test (Siegel 1956). An analysis of variance (Steel and Torrie 1960) was used to locate significant differences in body sizes and growth rates of PR and HR of both sexes. For each sex-rearing combination, body weights at day 25 and 31 were compared to locate significant decays (Ricklefs 1973) and growth rates using the Mann-Whitney U test (Siegel 1956).

The growth rate (K) and asymptote (A) of each component were computed for PR and HR birds by sex grouping according to the logistic model of Ricklefs (1967). For body weight, time for growth between 10 and 90% of the asymptote (t_{10-90}) and the ratio (R) between the asymptote and adult weight were calculated (Ricklefs 1967).

Results

Significant differences between PR and HR male kestrels were evident within 24 hrs of hatching for antebrachium (PR > HR) and manus length (PR < HR), as well as body weight (PR > HR) (Table 1). No significant differences were obtained for females at hatching.

There were significant differences in mean body component sizes of PR and HR, male and female kestrels (Table 2, Fig. 1). Furthermore, the significant age-rearing interactions demonstrated that PR kestrels grew faster than HR kestrels for all components except female skull width and bill length, as well as bill depth of both sexes (Table 2, Fig. 1).

The asymptotes (A), growth rates (K), and adult body sizes of the 7 skeletal measures are shown in Table 3. With the exceptions of female bill and toe lengths, where the asymptotes of HR birds were $\geq$ PR birds, the asymptotes and growth rates of PR birds exceeded those of HR birds. With respect to growth rate, these findings were consistent with the results shown in Table 2.

The growth rates of males were greater than females for 5 components (Table 3). This trend was most pronounced in development of toe and tarsus and least pronounced in manus and

Table 1. Mean body size (1 standard error) of parent-reared (PR) and hand-reared (HR) American Kestrels within 24 hrs post-hatching.

Body size Component	Male		Female	
	HR ^a	PR ^a	HR ^a	PR ^a
Skull width (cm)	1.56 (.03)	1.51 (.02)	1.50 (.04)	1.49 (.02)
Bill length (cm)	0.63 (.01)	0.64 (.01)	0.63 (.01)	0.64 (.01)
Bill depth (cm)	0.59 (.01)	0.59 (.01)	0.59 (.01)	0.60 (.01)
Tarsus length (cm)	1.41 (.02)	1.40 (.02)	1.36 (.02)	1.38 (.03)
Toe length (cm)	0.55 (.02)	0.62 (.01)	0.56 (.02)	0.58 (.01)
Antebrachium length (cm)	1.20* (.03)	1.12 (.08)	1.17 (.03)	1.16 (.04)
Manus length (cm)	1.36** (.03)	1.49 (.02)	1.40 (.04)	1.43 (.02)
Weight (g)	9.65** (.14)	10.96 (.12)	9.92 (.17)	9.99 (.31)

^a sample sizes: HR ♂, 13; PR ♂, 11; HR ♀, 12; PR ♀, 8.

*,** means of PR and HR kestrels are significantly different, Mann-Whitney U test, $P < 0.05$ (*) and $P < 0.01$ (**).

Table 2. Analysis of variance of 8 body components of captive male and female American Kestrel nestlings. The main effects in the analysis are age and rearing; one interaction term (age-rearing) is analyzed. Values are F-test statistics and are significant ($P < 0.01$) unless otherwise specified.

Body parameter	Male			Female		
	Age	Rearing	Age-Rearing	Age	Rearing	Age-Rearing
Skull width	165.3	17.0	4.5	134.3	7.6	1.9 NS
Bill length	386.3	57.3	3.4	345.6	23.1	1.3 NS
Bill depth	190.6	14.9	1.5 NS	145.0	8.0	0.8 NS
Tarsus length	868.5	97.8	7.8	576.8	49.0	4.4
Toe length	487.5	74.5	4.5	415.7	26.6	3.8
Antebrachium length	761.1	62.6	7.7	537.0	42.9	3.4
Manus length	702.3	56.4	5.3	628.1	28.3	3.5
Weight	499.9	136.1	15.1	374.6	61.6	10.6

NS Not significant.

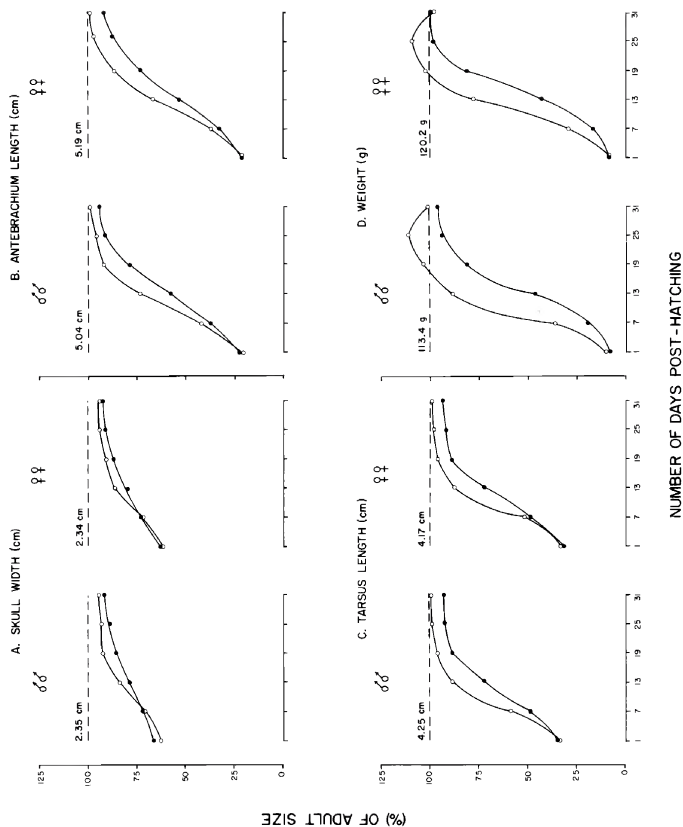


Figure 1. Growth of parent-reared (open circles) and hand-reared (closed circles) male and female, American Kestrels expressed as a percentage of adult size. Mean adult size, determined from parent-reared kestrels, is indicated along the top of each dashed line for: A. skull width; B. antebrachium length; C. tarsus length, and; D. body weight.

Table 3. Asymptotes (A) and growth rates (K) of 7 body components (cm) of parent-raised (PR) and hand-reared (HR) American Kestrels and associated mean (1 standard error) adult body sizes.^a

Body Component	Male				
	HR(13) ^b		PR(11)		Adult ^c (72)
	A	K	A	K	
Skull width	2.24	.079	2.30	.121	2.35(.02)
Bill length	1.21	.091	1.22	.131	--
Bill depth	0.94	.116	0.97	.125	0.89(.01)
Tarsus length	4.12	.165	4.29	.207	4.25(.04) ^d
Toe length	1.59	.188	1.71	.228	2.06(.03)
Antebrachium length	5.08	.143	5.27	.175	50.04(.03)
Manus length	5.49	.150	5.53	.172	--

Body Component	Female				
	HR(12)		PR(8)		Adult ^c (69)
	A	K	A	K	
Skull width	2.25	.087	2.27	.134	2.34(.01)
Bill length	1.22	.096	1.22	.120	--
Bill depth	0.96	.103	0.98	.115	0.93(.01)
Tarsus length	4.19	.146	4.36	.182	4.17(.03) ^d
Toe length	1.69	.150	1.68	.182	2.01(.02)
Antebrachium length	5.15	.137	5.35	.172	5.19(.03)
Manus length	5.43	.147	5.59	.164	--

^a A and K based on pooled data.^b sample size indicated in parentheses.^c mean adult size (1 standard error) from Bird, unpubl. data, of PR kestrels.^d sample sizes are: ♂, 11; ♀, 10.

antebrachium. The growth constant of skull width for females was greater than for males, but no consistent pattern was evident with bill length.

Asymptotes and growth constants for body weight of PR birds were substantially greater than those of HR birds (Table 4). Rate of weight gain of males exceeded females. Although weight was an extremely variable component, females were approximately 6 g heavier than males at, and subsequent to, fledging (Table 4).

Based on the predictive model of Ricklefs (1968: 436), the t_{10-90} values of males and females would be 15.3 and 15.5 days respectively. However, our corresponding calculated values for PR males and females were 17.6 and 18.4 days. Therefore, weight gain of captive kestrels was relatively slow. The weight loss observed between days 25 and 31 post-hatching

Table 4. Asymptote (A), growth rate (K), number of days required for growth between 10% and 90% of asymptote t_{10-90} and the ratio (r) of the asymptote to adult size for weight (g) of parent-reared (PR) and hand-reared (HR) American Kestrels.^a

Growth parameter	Male		Female	
	HR(13) ^b	PR(11)	HR(12)	PR(8)
A	118.9	132.6	130.1	137.7
K	.209	.250	.203	.239
t_{10-90}	21.0	17.6	21.6	18.4
Adult weight (S.E.) ^c		113.4(2.0)		120.2(5.3)
R	1.05	1.17	1.08	1.15

^a based on pooled data.

^b sample size indicated in parentheses.

^c weight (1 standard error) based on 25 ♂ and 26 ♀ from Bird, unpubl. data, on parent-reared birds only.

(Fig. 1) was also reflected in the ratios of the asymptote to adult weight ($R > 1.0$), signifying that the decay phase continues through the early post-fledging period (Table 4).

In Figure 1, growth of PR and HR, male and female kestrels is expressed as the percentage of adult body size. At 31 days post-hatching, skull width had not achieved adult size (Fig. 1a), its growth to be completed following fledging. The K values for tarsus length were higher for the PR birds and for males than for the HR birds and for females, respectively (Fig. 1c). Rapid growth of the antebrachium, primarily between 7 and 19 days post-hatching, resulted in PR nestlings achieving roughly 98.5% of adult size at fledging (31 days) (Fig. 1b). HR birds lagged behind PR birds by approximately 5.5% at this date. The maximum weight of PR kestrels at 25 days post-hatching was followed by a significant weight loss or decay ($P < 0.05$; Fig. 1). A decay phase for HR birds was not observed.

Discussion

The values of A, K, t_{10-90} and R as shown for body weight in Table 3 are somewhat less than those computed by Ricklefs (1968) from data published by Roest (1957) for 13 wild kestrels from 3 broods. This is especially true for our HR birds. Bird and Laguë (1982) showed that their HR kestrels were permanently smaller as adults than PR ones in skull width, tarsal length, antebrachium and manus length, but not body weight.

In this study, the A and K values, as well as the means of body components, indicated that PR birds grew more rapidly and achieved greater size than HR birds. Since both PR and HR birds received a similar diet, we conclude that differential feeding rates were the main factor limiting rates of growth. We cannot disprove the possibility that different incubation regimes, i.e. natural vs. artificial, for PR and HR birds respectively may have contributed some variation, although Bird and Laguë (1982) noted no effect of incubation technique on fresh chick weight in their captive kestrels.

Our results suggest that for raptors, food limitation can prolong nesting period or result in smaller offspring, as shown in swifts (Lack and Lack 1951) procellariiforms (Lack 1948), and

Red-winged Blackbirds (*Agelaius phoeniceus*) (Dyer 1968). Smaller sizes are often equated with lowered survival probabilities of offspring (Perrins 1965, Thomsen 1971). Although Balgooyen (1976) found no differences in rates of body weight growth of wild kestrels associated with observed differences in feeding rates, he noted that food was likely not a limiting factor, especially when young received food from both parents.

The significant decay in body weight which occurred immediately prior to fledging concurs with Olendorff's (1974) findings in 3 buteo species. The most tangible hypothesis proposed to explain this phenomenon is that substantial water loss occurs as feathers and muscle tissues mature immediately prior to fledging (Ricklefs 1968). It is unlikely that adults starve nestlings to cause nest abandonment (Sumner 1929, Welty 1979), since hand-reared birds exhibit this weight loss (Olendorff 1974, Schmutz and Schmutz 1975, Bird and Laguë 1982).

Growth rates of males, particularly the third toe and tarsus, were greater than those of females. The Cooper's Hawk (*Accipiter cooperi*) and Red-tailed Hawk (*Buteo jamaicensis*) also exhibited this phenomenon (Ricklefs 1968). To explain this pattern in the Sparrowhawk (*Accipiter nisus*), Newton (1978) hypothesized that in species where the male is smaller than the female, the male grows more rapidly to avoid, or reduce, competition in the nest. Werschkul and Jackson (1979) argued that sibling competition is an important determinant driving the evolution of avian growth rates. We found growth in leg components of males faster than females in both rearing groups, which presumably makes smaller males more mobile and potentially able to leave the nest sooner. However, relationship between size of bird and length of development time derived from numerous families of avian species (Ricklefs 1973) may be sufficient to explain these trends. Thus, we believe further research examining competitive interactions among siblings is required to demonstrate that growth rates are a consequence of natural selection acting to reduce competition (see Ricklefs 1982).

In conclusion, food limitation resulted in slower growth rates and smaller body sizes through 31 days of age in captive kestrels. One must be cautious in using hand-rearing techniques for growth studies and propagation of captive avian species for release into the wild.

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Literature Cited

- Balgooyen, T.G. 1976. Behavior and ecology of the American Kestrel (*Falco sparverius* L.) in the Sierra Nevada of California. Univ. Calif. Publ. Zool. 103:1-83.
- Bird, D.M. 1982. American Kestrel as a laboratory research animal. *Nature* 299:300-301.
- Bird, D.M. and P.C. Laguë. 1982. Influence of forced renesting and hand-rearing on growth of young captive kestrels. *Can. J. Zool.* 60:89-96.
- Bird, D.M. and N.B. Rehder. 1982. The science of captive breeding of Falcons. *Avic. Mag.* 87:208-212.
- Bird, D.M., P.C. Laguë, and R.B. Buckland. 1976. Artificial insemination vs. natural mating in captive American Kestrels. *Can. J. Zool.* 54:1183-1191.
- Dyer, M.I. 1968. Respiratory metabolism studies on Red-winged Blackbird nestlings. *Can. J. Zool.* 46:223-233.
- Lack, D. 1948. The significance of clutch size. Parts 1 and 2. *Ibis* 89:302-352.

- Lack, D. and E. Lack. 1951. The breeding biology of the Swift (*Apus apus*). *Ibis* 93:501-546.
- Newton, I. 1978. Feeding and Development of Sparrowhawk (*Accipiter nisus*) nestlings. *J. Zool. (Long.)* 184:465-487.
- . 1979. The population ecology of raptors. Buteo Books, Vermillion S.D. 399 pp.
- Olendorff, R.R. 1972. On weighing and measuring raptors. *Raptor Res.* 6:53-56.
- . 1974. Some quantitative aspects of growth in three species of buteos. *Condor* 76:466-468.
- Perrins, C.M. 1965. Population fluctuations and clutch-size in the Great Tit, *Parus major*. *Anim. Ecol.* 34:601-647.
- Ricklefs, R.E. 1967. A graphical method of fitting equations to growth curves. *Ecology* 48:978-983.
- . 1968. Patterns of growth in birds. *Ibis* 110:419-451.
- . 1973. Patterns of growth in birds. II. Growth rate and mode of development. *Ibis*. 115:177-201.
- . 1982. Some considerations on sibling competition and avian growth rates. *Auk* 99:141-147.
- Roest, A.I. 1957. Notes on the American Sparrow Hawk. *Auk* 74:1-19.
- Schmutz, S.M. and J.K. Schmutz. 1975. Rearing and release of two young American Kestrels (*Falco sparverius*). *Raptor Res.* 9:58-59.
- Siegel, S. 1956. Nonparametric statistics for the behavioral sciences. McGraw-Hill Book Co., Inc., New York.
- Steel, R.G.D. and J.H. Torrie. 1960. Principles and procedures of statistics. McGraw-Hill Book Co., Inc., New York. 481 pp.
- Sumner, E.L., Jr. 1929. Comparative studies on the growth of young raptors. *Condor* 31:85-111.
- Thomsen, L. 1971. Behavior and ecology of Burrowing Owls on the Oakland Municipal Airport. *Condor* 73:117-192.
- Welty, J.C. 1979. The life of birds. 2nd Edition. Saunders College Publ., Philadelphia, Pa. 623 pp.
- Werschkul, D.F. and J.A. Jackson. 1979. Sibling competition and avian growth rates. *Ibis* 121:98-102.

THE PRICE OF SUCCESS IN GOSHAWK TRAPPING

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Abstract

Four Swedish traps for goshawks are described. Falling-end traps were most successful of 3 live-bait trap types, but were more expensive to build and less easily moved than sprung-roof

and falling-lid traps. The latter 2 types were equally successful, but the falling-lid trap cost least time and money to build. An automatic spring-net baited with a hawk's kill was successful, and more selective of resident hawks, than the live-bait traps.

Introduction

In field studies of raptors, effective and inexpensive live-capture techniques are needed. A variety of trap designs have been published in falconry books and wildlife journals (e.g. Mavrogordto 1960, Beebe & Webster 1964, Meng 1971, Berger & Hamerstrom 1962). Some types, using mist-nets or nooses, require more or less constant attendance; whereas other 'containment' traps are less labour intensive because they secure the raptor inside and can therefore be checked much less frequently. Fuller & Christenson (1976) compared the capture rates of mist-nets and bal-chatri with 2 'containment' types (the 'Swedish' goshawk trap (Meng 1971) and an automatic bow-net) in different habitats, for catching mainly buteos and owls. We compare capture rates, building time, and cost of 4 Swedish 'containment' goshawk traps, 3 of which appear not to have been described in English.

Materials and methods

Sprung-roof trap

This design, originally attributed to Knöppel (Hamilton et al. 1947), was used as described by Meng (1971), except that the sides were extended upwards to form a frame round the top (Fig. 1). Without the extra support this modification provides, the spring-loaded roof sections are liable to operate prematurely in windy weather or when a hawk alights on them prior to entering the body of the trap. One or 2 domestic pigeons (*Columba livia*) were used as bait, dark plumage during snowcover and light colours at other times.

Falling-lid trap

These were modified from a design by Hamilton (Lundberg 1933), having a box frame with 70 cm edges, in which a single horizontal sheet of wire netting separated pigeons in the lower third from the upper capture compartment. A vertical pole projected 60 cm up from the center of one side, to which a heavy lid was hinged, and near the pole's top a metal strip was center-pivoted so that a hook on one end held the lid about 80° open (Fig. 2). A wire from the opposite end of the pivoted strip ran down through the top of that side of the trap to the center of the somewhat flexible partition above the pigeons, so a hawk entering the upper compartment pulled the wire to pivot the metal strip and let the lid fall under gravity.

Falling-end trap

This design was 80-110 cm wide, 190-220 cm long and 80-90 cm high, the ends being closed by heavy doors which dropped vertically in side runners (Fig. 3). A narrow central compartment containing pigeons was separated by vertical partitions from a capture compartment at each end. Two break-back rat traps were mounted on top so that a wire cable from each breaker could jerk out a hook holding one door up. A hawk entering encountered fine wires fixed across the capture compartment near the inner partition like an inverted 'T', of which the 'arms' were fastened to the sides ca 5 cm above the bottom and the 'stem' attached through the roof to the break-back trigger plate. For catching raptors the minimum dimensions were used and the sides could be covered with chicken netting, in which case the traps had to be sited so that foxes (*Vulpes* sp.) or other large mammal predators could not enter. Otherwise it was

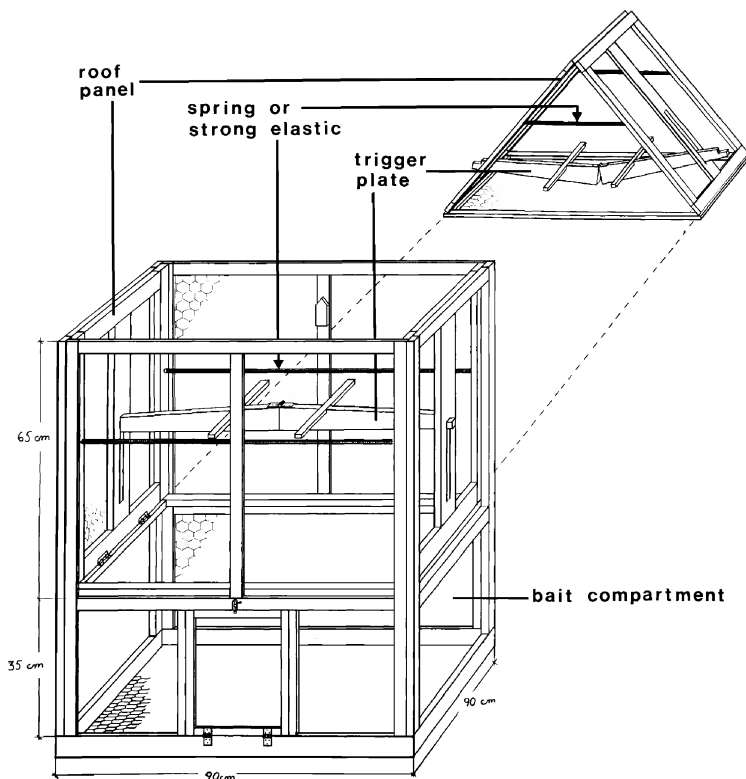


Figure 1. Sprung-roof trap, shown in set position. Inset shows the trap in sprung position.

necessary to use heavy duty chain-link netting, fitted inside the wood frame of capture compartments, because trapped mammals damaged the frame by trying to gnaw out. In this case the bait compartment had an inner lining of fine mesh chicken netting to protect the pigeons. Herman Karlsson developed this trap, which is frequently called the 'Nyborg trap' after the estate where he worked (Högfeldt 1954).

Automatic spring-net

These were baited with the part-eaten carcass of a hawk's kill, which was attached to the trigger plate of a mechanism for releasing a square, spring-loaded frame spanned by a net (Fig. 4). The frame and folded net would normally be covered with leaves and feathers from the kill, and arranged so a hawk would tend to approach from end A. This trap can be used with a stuffed bird as bait. The bait's head should be pointing towards end B so that the hawk is heading into the net as it strikes the 'prey' from behind.

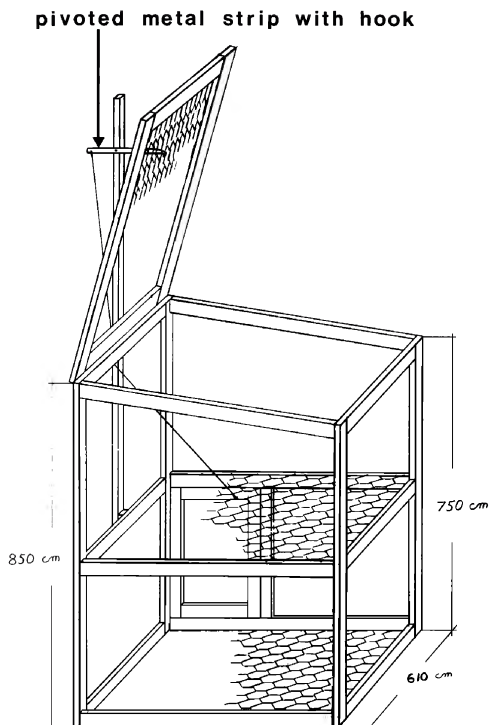


Figure 2. Falling-lid trap, in set position.

Trapping

The first 3 trap types were set either near pheasant feeding areas or in other sites with good visibility through at least 180°, and if possible with a nearby tree in which approaching hawks could perch. Traps were sited where they were unlikely to attract human interference, but most could be seen by looking carefully from roads, which facilitated checks within 2 hr of dawn, at midday and at dusk. Pigeons were fed and watered once a day. There was transparent plastic sheeting in one corner of the bait compartment as shelter against wind or rain, and pigeons were removed in very poor weather. Spring-nets were set when kills were found, and checked at the same times as the other types until a hawk was caught or for 2 days.

The traps were used in 2 areas, described elsewhere (Kenward 1977, Kenward et al. 1981). At Frötuna estate there were 6-8 falling-lid traps, 1 falling-end trap, and up to 3 spring-nets in use at a time. At Segersjö there were 2 falling-lid traps, with 1 falling-end trap, 2 sprung-roof traps and occasional use of 2 spring-nets.

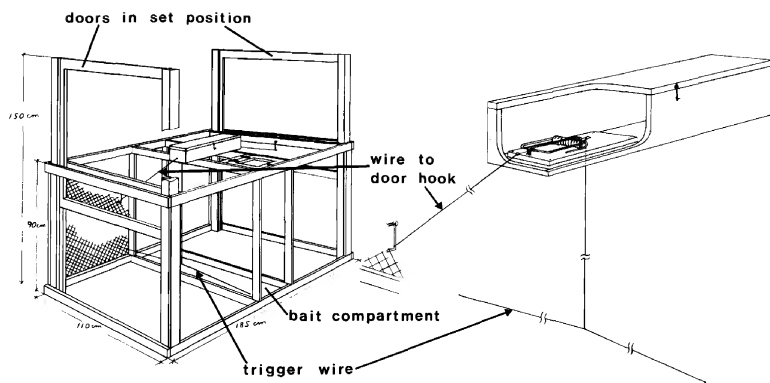


Figure 3. Falling-end trap. Inset shows detail of break-back trap trigger mechanism.

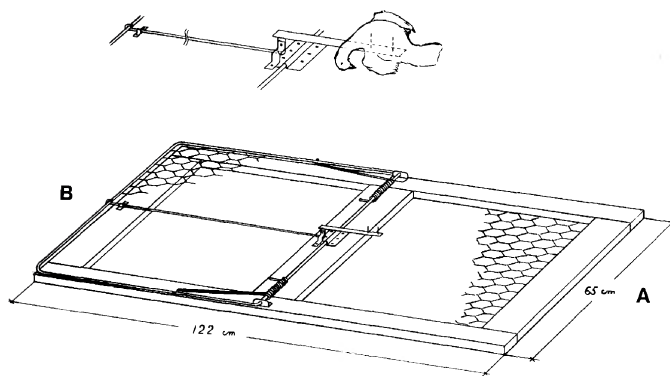


Figure 4. Automatic spring-net in set position; inset with bait.

Results & Discussion

Falling-end traps had higher capture rates than falling-lid or sprung-roof traps (Table 1), the difference being significant in comparison with the falling-lid type at Frötuna ($\chi^2(1) = 21.17$, $P < 0.001$). It is unlikely that the hawks could see the bait most easily in the falling-end traps, because the wire sides tend to conceal pigeons more than in the falling-lid and sprung-roof types, and the falling-end trap at Frötuna was in one of the least conspicuous positions. Falling-end traps were most successful, probably because hawks often run round traps on the ground, trying to get at the bait from the side, and do not always discover the top opening of other trap types (Högfeldt 1954). Falling-end traps can catch two hawks at the same time: before the study, this trap at Frötuna caught a goshawk in one end and a Golden Eagle (*Aquila chrysaetos*) in the other (L. Lans, pers. comm.).

Capture rates at Segersjö were lower than at Frötuna (Table 1), the difference being significant for the falling-end traps ($X^2(1) = 4.62$, $P < 0.05$), probably because hawk densities were 4 times higher at the former site (Kenward et al, 1981), where about 4,000 pheasants were released annually; no pheasants were released at Segersjö.

The automatic spring-nets were the most successful traps, and caught hawks almost every time they were set with a fresh kill unless they were sprung by corvids (*Garrulus glandarius*, *Pica pica*) or locked by moisture freezing on the mechanism. Hawks at Frötuna returned to eat again from 71% of their pheasant kills (Kenward 1977), and 3 hawks were caught in spring-nets baited with pheasants killed by other (radio-tagged) hawks.

Table 1. Capture success and cost of Swedish goshawk trap types in 2 study areas.

	Sprung-roof	Falling-lid	Falling-end	Spring-net
Trap-days/capture (N of captures) at Frötuna		24 (34)	7 (18)	2 ^a (31)
Trap-days/capture (N of captures) at Segersjö	23 (14)	31 (13)	16 (11)	2 (3)
Cost of trap material (\$)	35-50	25-30	70-85	50-55
Building time (hrs)	10-15	4-6	10-15	b

a Approximate figure, in absence of precise records of trap days.

b Cost of trap from AB Vapen-Depöten, FALUN, Sweden.

No hawk deaths occurred in the 123 trap events. One hawk lost the end of its tongue, which tangled in spring-netting, and 1 received a deep cut when the trigger wire of a falling-lid trap came loose and twisted round the bird's leg. Both birds, which were radio-tagged, survived for at least 3 months afterwards. Some hawks scraped skin from the top of their heads, but this healed quickly in retrapped or captive birds. Minor injuries and occasional broken feathers probably had little adverse effect on survival, and all these traps could routinely be used to trap hawks at game farms for release elsewhere (Marcström & Kenward 1981).

There was no marked tendency for any of the 3 pigeon-baited trap types to catch more male, female, adult or juvenile hawks than the others, but sample sizes were small (Table 2). However, the proportion of males was higher among hawks caught in spring-nets than in traps baited with live pigeons, inter-trap differences being significant among first captures at Frötuna ($X^2(2) = 5.68$, $P < 0.05$). One reason for spring-nets selecting males was that a higher proportion of males than females took pheasants, both at Frötuna (6 of 6 males, 4 of 7 females) and at Segersjö (3 of 8 males, 1 of 6 females), although these differences were not significant.

Table 2. Age and sex classes of hawks taken in four different trap types.

Trap type	At Frötuna				At Segersjö			
	Male		Female		Male		Female	
	Juvenile	Adult	Juvenile	Adult	Juvenile	Adult	Juvenile	Adult
Sprung-roof					5	3	1	5
Falling-lid	16	3	11	4	7	1	4	1
Falling-end	7	2	7	2	6	2	2	1
Spring-net	18	8	2	3	1	1	0	0

All nine hawks which were radio-monitored for more than a week at Frötuna were caught in spring-nets at least once, compared with only 1 of 4 hawks which left within a week (Fisher exact test, $P = 0.014$). All 9 hawks that stayed took pheasants, whereas the other may have been spring-netted on another hawk's kill. Two of the 4 hawks that killed pheasants at Segersjö were spring-netted, compared with none of 9 others, and all the spring-netted hawks remained in the area for several weeks. Thus, spring-nets caught almost exclusively hawks which killed pheasants, and not hawks passing through the study areas.

One further type of live-baited containment trap is used in Germany. This "butterfly" clap-net is less bulky and hence more portable than the Swedish live-baited types, but pigeons are less easy to see from a distance. Hawks do not have to enter a capture compartment, and capture rats for this trap may therefore be at least as high as for the Swedish types provided that pigeons can be detected easily by hawks.

Conclusions

Where kills could be found easily, as at sites visited regularly to feed pheasants, spring-nets required the least effort to operate per captured hawk. They were also the most portable, and therefore very suitable for recapturing radio-tagged hawks when these could be located with relatively large prey. For routine capture of hawks where kills were scarce or too small to use as spring-net bait, falling-end traps gave best success rates, but falling-lid types might be preferred to reduce construction costs and facilitate movement of traps. Spring-traps were more selective than live-baited traps for hawks which stayed in areas and killed pheasants.

Literature Cited

- Beebe, F., and H. Webster. 1964. North American falconry and hunting hawks. World Press, Denver.
- Berger, D.D., and F. Hamerstrom. 1962. Protecting a trapping station from raptor predation. *J. Wildl. Manage.* 26:203-206.
- Fuller, M.R., and G.S. Christenson. 1976. An evaluation of techniques for capturing raptors in east-central Minnesota. *Raptor Res.* 10:9-19.
- Hamilton, H., B. Haglund, and O. Knöppel. 1947. Fällor, fångstmetoder, hjälpfodring m.m. In Svenska Jägareförbundet: Viltvård, pp. 223-225. Lantbruksförbundets tidskriftsak-tiebolag, Stockholm.

- Högfeldt, N. 1954. Nyborgsfällan för rovdjursfångst. *Svensk Jakt*. 92:238.
- Kenward, R. 1977. Predation on released Pheasants (*Phasianus colchicus*) by Goshawks (*Accipiter gentilis*) in central Sweden. *Viltrevy* 10:79-112.
- Kenward, R.E., V. Marcström, and M. Karlbom. 1981. Goshawk winter ecology in Swedish Pheasant habitats. *J. Wildl. Manage.* 45:397-408.
- Lundberg, A. 1933. Hanbok för jaktvårdare. Fahlcranz & Co., Stockholm.
- Marcström, V., and R. Kenward. 1981. Movements of wintering goshawks in Sweden. *Swed. Wildl. Res.* 12:1-35.
- Mavrogordato, J.G. 1960. A hawk for the bush. Witherby, London. 1973 2nd ed. Neville Spearman, London.
- Meng, H. 1971. The Swedish Goshawk trap. *J. Wildl. Manage.* 55:832-835.

OBSERVATIONS ON NESTING WHITE-TAILED HAWKS

by

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During the period 16 July to 20 August 1977, I observed and photographed adult and young of the White-tailed Hawk (*Buteo albicaudatus*), at a nest on Laguna Atascosa National Wildlife Refuge, Texas. Observation began when 2 young were approximately 2 days old, and continued at 7 day intervals. A 500 mm telephoto lens and 35 mm camera were used to photograph and observe the birds.

The nest was a platform of woody stems placed between two branches of a Spanish dagger or Spanish bayonet (*Yucca treculeans*), 2.7 m above the ground. The nest was about 1 km west of Laguna Madre Bay on an open ridge among scattered mesquite (*Prosopis* spp.) and Spanish dagger. Observations were made from a blind 2.7 m above the ground, approximately 18 m from the nest.

During my first visit (16 July) I saw only one nestling. By 23 July both young were active and one was visibly larger than the other. When they were being fed, the larger one became dominant and maneuvered into a position to receive most of the food when it was in limited quantity. When feeding was first observed (23 July), the smaller nestling was too weak to sit erect for more than a few seconds, while the larger sibling was erect and prepared to take most of the food brought to the nest. By 30 July there were still signs of dominance, although the size difference was no longer recognizable. On 13 August and 20 August the young fed themselves from prey left at the nest.

The adults were seen during each of my visits, which extended from before sunrise (time unknown) until 1200-1400 hours. From daylight until approximately 0930 hours both perched on Spanish dagger plants 20-50 m from the nest. I assumed these sites were used as night roosts. The adult hawks left their perches, presumably to hunt, during mid-morning (0930 - 1030 hours). One adult invariably returned with food between 1030 and 1100 hours. After feeding the young or depositing its catch in the nest, the adult again perched and preened at or near the nest for varying periods.

I was not able to identify all of the prey, but at least 7 different species were eaten by the young including: eastern yellow-bellied racer (*Coluber constrictor flaviventris*), western ribbon snake (*Thamnophis proximus*), Texas horned lizard (*Phrynosoma cornutum*), Mexican ground squirrel (*Citellus mexicanus*), cottontail rabbit (*Sylvilagus floridanus*), blue crab (*Callinectes sapidus*), and an unidentified small, long-tailed rodent.

During my last two visits, when the young were estimated at between 30 and 37 days of age, they frequently alternated between stretching and flapping their wings. The young used the nest edge and its supporting branches as exercising perches. Exercising included extending the wings to catch the wind and then springing into the air, hovering momentarily over the perch, alighting, and hovering again.

The 2 young were still in the nest at my final visit on 20 August.

OSPREY CAPTURES MAMMAL AT EDGE OF SOYBEAN FIELD

by

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and

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Diets of Osprey (*Pandion haliaetus*) consist almost exclusively of live fish (Sherrod 1978). Many non-fish items, however, have been recorded and these were reviewed by Wiley and Lohrer (1973) along with proposed explanations for Osprey preying on non-fish foods. Reasons given to explain this phenomenon are: scarcity of fish, unusual abundance of non-fish prey, temporarily unfavorable fishing conditions, poor fishing abilities of young Osprey, and unusual opportunities to take crippled, captive, or concentrated prey items. This note reports an additional reason based on the observation of an Osprey in a very atypical habitat capturing a mammal.

While walking in a soybean field on 18 April 1983 at 1330 in eastern Scott County, Indiana, we saw a large raptor flying low to the ground at the edge of the field. The low flight, long wings, and open habitat initially suggested a Northern Harrier (*Circus cyaneus*). More careful inspection, however, showed that it was an Osprey. The bird's flight was suddenly interrupted as the Osprey wheeled and pounced. Because of the topography of the field, the bird could not be seen at the base of the slope. It appeared, however, to be on the ground at the grassy edge of the soybean field bordered by a woodlot. After several seconds, the Osprey was seen flying above the treeline. Because of the strong, gusting winds, the bird banked several times before flying off. Grasped in its talons was a mammal that appeared to be an eastern mole (*Scalopus aquaticus*) due to its size, shape, coloration, and lack of a long tail. At any case, it was definitely a small mammal that appeared to have been recently killed. Moles have not been recorded in the diets of Osprey (Wiley and Lohrer 1973), although they are occasionally taken by other raptors (Sherrod 1978).

Osprey are listed as rare migrants and very rare summer residents in Indiana (Keller et al. 1979). Osprey migrating through inland agricultural areas in Indiana will find little optimal wetland habitat for hunting and may be forced to search for alternative prey in suboptimal habitats. The observations we made suggest that at least some Osprey have the behavioral plasticity to successfully do so.

These observations were made while conducting research funded by Indiana Federal Aid to Wildlife Restoration Project W-26-R and the Indiana Division of Fish and Wildlife.

Literature Cited

- Keller, C.E., S.A. Keller, and T.C. Keller. 1979. Indiana birds and their haunts. Indiana Univ. Press, Bloomington. 214pp.
- Sherrod, S.K. 1978. Diets of North American Falconiformes. *Raptor Res.* 12:49-121.
- Wiley, J.W., and F.E. Lohrer. 1973. Additional records of non-fish prey taken by Ospreys. *Wilson Bull.* 85:468-470.

SCREECH OWL TRAPPED INSIDE FALLEN ROOST TREE

by

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and

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Although the Screech Owl (*Otus asio*) habitually roosts in cavities in dead or partially dead trees, little information is available on mortality related to the felling of roost trees; e.g. Sutton (*Auk* 44:563-564) reported only one of 111 cases of known mortality due to felling of a tree (apparently by man). Sixteen of 82 (19.5%) Screech Owl tree cavity roost sites we located during an 8 year study in southern Connecticut were in dead snags or partially dead trees. Eight of these have since been destroyed by storms or as a consequence of natural decay. A known cavity roost in East Haven, Connecticut was visited on 19 December 1979. The cavity opening was about 0.1 m from the top of a 3.5 m dead pignut hickory (*Carya glabra*) trunk. A subsequent visit on 27 December at 1620 EST showed that the trunk had fallen with the cavity opening face down, leaving an owl trapped inside. During an effort to roll the trunk, the back wall of the cavity collapsed, allowing the owl to escape. The owl appeared uninjured, judging from its unhindered flight.

Prior to this incident, an owl at this station had regularly responded to playback of tape-recorded Screech Owl calls. Following this incident, all attempts to elicit responses were unsuccessful and we suspect that the owl had abandoned that territory.

We thank Richard J. Clark for suggestions regarding this note.

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JUNE RECORD FOR GYRFALCON IN SOUTH DAKOTA

by

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On 10 June 1979, I was observing the Black-billed Magpie (*Pica pica*) as part of a long-term study in Wind Cave National Park of the Black Hills, Custer Co., South Dakota. At 2:07 PM, I was alerted by the alarm cries of several magpies at a nest approximately 200 m away. I observed a large, light colored raptor flying directly towards me at a rapid, steady speed, 10-15 m above the ground. I knew immediately that it was neither a Prairie Falcon (*Falco mexicanus*) nor a Red-tailed Hawk (*Buteo jamaicensis*), two raptors I had observed in the park during the study. It was uniformly whitish in color with black speckling and lacked the black axillars of a Prairie Falcon. The wing span was approximately the same as a large buteo. The body was strikingly stout and the tail wide but tapered in slightly towards the end. The wingbeat was slower than that of the low-flying Prairie Falcon. I identified it as a Gyrfalcon (*Falco rusticolus*).

Whitney et. al. (The Birds of South Dakota, Buteo Books, Vermillion, SD, 1978) list the status of the Gyrfalcon in South Dakota as an "irregular, rare to uncommon winter visitant". The latest recorded spring date for South Dakota was 23 April 1955 at Wall Lake by Krause (*South Dak. Bird Notes* 7:48, 1955).

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FOUR KESTRELS DEFEND NEST BOX CONTAINING EYASSES

by

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Although the pre-nesting association of the American Kestrel (*Falco sparverius*) may initially be characterized by promiscuous matings (Cade 1955, Balgooyen 1976), monogamous pairs form several weeks prior to egg-laying (Cade 1982). Wegner (1976) observed 2 male kestrels alternately bringing prey to the same female at a nest containing 5 young in New York; a possible deviation to monogamy by this species. However, he did not comment on nest defense, and to my knowledge, no one has previously documented defense of the same nest by more than 2 kestrels. Defense of the nest and young was described in detail by Balgooyen (1976), who noted that humans at kestrel nests were attacked more vigorously by male than female kestrels during incubation, but the reverse was true after eggs hatched. This report describes the behavior of 4 free-flying kestrels that defended a nest box containing 3 downy young.

As part of a study of kestrel use of reclaimed surface mines in West Virginia and Pennsylvania (Wilmers 1982), 3 nest boxes (1 in 1980, 2 in 1981) were available on the Lazzelle Cemetery Mine (2.5 mi. southwest of Maidsville, West Virginia). This 30 ha site, reclaimed to grassland in 1976, was surrounded primarily by woodland, although some old-field habitat and pasture land were proximal (see Wilmers 1982:26-27 for a detailed site description). Natural cavities suitable for kestrels were lacking on both the mine and adjacent areas. Nesting by kestrels did not occur on this mine in 1980.

On 17 May 1981, I visited this mine and found 1 nest box (no. 16) empty, but the other box (no. 30) contained a clutch of kestrel eggs that had broken due to a faulty nest box floor. Defense of this nest was not observed, although 2 kestrels were seen nearby. I repaired the box's floor and removed the broken eggs.

I revisited the mine on 28 May (copulation observed) and twice during June, but did not climb to either nest box because if the pair had re-nested, incubation would be in progress, and they may have been sensitive to human-caused disturbance during this period (Fyfe and Olendorff 1976). On 17 July 1981, I climbed to both boxes. Box no. 16 contained a single kestrel pellet but was otherwise empty. At box no. 30 (1731 hr) a silent female kestrel made 3 wide circles above the nest, using the flutter-glide motion (see Willoughby and Cade 1964). No kestrels were heard or seen as I ascended the nest box tree. Three kestrel nestlings (considerable down was present on their bodies) and 1 unhatched egg were inside. A silent male kestrel dove within about 1 m of my head, and then began klee-calling (Willoughby and Cade 1964). At least 1 male kestrel then made about 10 close passes within a 2 min. period. I thought that 2 males were involved in defense of the nest, and climbed to the upper tree canopy to determine the location of the birds. I observed 4 kestrels perched within 10 m of each other on dead limbs of a large ash (*Fraxinus americana*), less than 200 m from the nest box. One left its perch, dove past me twice, and returned to the ash. At least 2 birds were now klee-calling. About 1 minute later, the 4 kestrels departed from the ash, and 3 of them made close dives (within 5 m of me): 2 were males, the other a female. The fourth made a less vigorous dive about 20 m from the nest; its sex was not determined. Three of the birds flew back to the ash after a single dive; but 1 of the males made 5-6 successive dives, and then flew back to join the other birds. After approximately 15 sec. 1 of the kestrels made a direct flight of at least 1 km over an adjacent woodland, and disappeared. A second one flew to the edge of the mine, and was last seen perched there. The other 2 kestrels remained perched in the ash tree. The time was now 1752 hr.

Prior to 17 July 1981, I did not observe more than 2 kestrels on the Lazzelle mine, and for this reason, I believe that only 2 birds reared the young. The 2 "extra" kestrels that defended the nest might have been juveniles that dispersed onto the Lazzelle site from nests on mines nearby. Four of 7 kestrel nests on 4 mines situated within 5 km of the Lazzelle site were successful in 1981, producing 12 young (all fledged prior to 21 June). Certainly the date (17 July) was late enough for these young to have dispersed from the mines where they were born. After fledging, family groups of kestrels composed of adults and their young remained together for 3 weeks in Utah, and then dispersed (Smith et al. 1973). In California, dispersal of juveniles from nesting territories occurred as early as 2 weeks after formation of family groups (Cade 1955). Adult kestrels of both sexes tolerate the intrusion of dispersing juveniles into their territory (Balgooyen 1976).

Acknowledgments

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Literature Cited

- Balgooyen, T.G. 1976. Behavior and ecology of the American Kestrel (*Falco sparverius* L.) in the Sierra Nevada of California. Univ. of Calif. Publ. Zool. 103:1-83.
- Cade, T.J. 1955. Experiments on the winter territoriality of the American Kestrel, *Falco sparverius*. *Wilson Bull.* 67:5-17.
- Cade, T.J. 1982. The falcons of the world. Comstock/Cornell Univ. Press, New York. 192pp.
- Fyfe, R.W., and R.R. Olendorf. 1976. Minimizing the dangers of nesting studies to raptors and other sensitive species. Can. Wildl. Serv. Occas. Pap. 23. Edmonton, Alberta. 17pp.
- Smith, D.G., C.R. Wilson, and H.H. Frost. 1972. The biology of the American Kestrel in central Utah. *Southwestern Nat.* 17:73-83.
- Wagner, W.A. 1976. Extra-parental assistance by male American Kestrel. *Wilson Bull.* 88:670.
- Willoughby, E.M., and T.J. Cade. 1964. Breeding behavior of the American Kestrel (Sparrowhawk). *Living Bird* 3:75-96.
- Wilmers, T.J. 1982. Kestrel use of nest boxes on reclaimed surface mines in West Virginia and Pennsylvania. M.S. Thesis. D.Va. Univ., Morgantown. 182pp.

ABSTRACTS OF THESES AND DISSERTATIONS**NESTING BEHAVIOR OF THE FERRUGINOUS HAWKS (*Buteo regalis*)**

Behavioral data were gathered from 1972 to 1974 at 12 Ferruginous Hawk (*Buteo regalis*) nests in Curlew Valley of southeastern Idaho and northern Utah. Although Ferruginous Hawks occupied territories from mid-March through mid-July, courtship activity may have begun on winter territories or enroute to summer nesting territories. Courtship flight in the traditional sense was not observed during the study. Other preincubation behaviors likely functioned in courtship or pair formation and maintenance. These included the gathering and delivery of nest materials, arranging the nest, and food transfer.

Seasonal utilization of perches revealed little difference in the type of perch preferred during the preincubation period, whereas incubation and brooding behavior favored tree and ground perches. Throughout the breeding season favorite ground perches were utilized for resting, prey transfer, feeding and nest sanitation.

Both prominent perching and flight display were conspicuous forms of territorial advertisement and defense during preincubation. Only male hawks were observed hovering, and then only when winds exceeded 20 km/h. Regular soaring occurred primarily in context of territorial defense and hovering. Associated with aggression, follow-soar usually functioned in escorting intruders out of the territory. Buoyant flight may function in advertisement or pair contact but seems also to operate in more aggressive, territorial advertisement and defense in both conspecific and interspecific contexts.

Few conspecific encounters were observed. More interactions occurred with Swainson's Hawks than any other buteo, yet aggression was of relatively low intensity and Swainson's Hawks often successfully interspersed their territories around established Ferruginous Hawk nests. Defense against large avian predators (eagles) or large ground predators (coyotes) involved cooperative, alternating attacks by the resident pair of Ferruginous Hawks. Little interaction occurred with other avian species observed within Ferruginous Hawk territories.

Incubation behavior data were gathered during 60h of observation in 1974 at three nests. At each nest site both sexes incubated, the number of shifts nearly equal for males (23) and females (27), although the females incubated 69.4% of the total incubation time and males 30.6%. The mean time per parent shift for male (49.2 ± 50.4) was significantly less than for females (91.5 ± 72.4 min). Males incubated more (71.1%) during the early half of the day, and were not known to incubate at night. Nests with eggs were seldom left unattended by either adult.

Adult and young hawks both exhibited adaptations to a hot, dry environment. Nestlings evidenced physical discomfort during times of high ambient temperatures, particularly in the absence of shade, wind, or cloud cover. During such periods the nestlings employed a variety of thermoregulatory mechanisms to alleviate the problem. The overall mean body temperature for two nestlings on seven dates between 31 May and 23 June was $40.3 \pm 0.9^\circ\text{C}$. Midday fluctuations of body temperature from 38.5 to 43.5°C indicated a tolerance of hyperthermia. Nesting behavior thermoregulatory mechanisms included shade-seeking, nest-edge-perching, wind-orienting, panting, wing-drooping, feet-out-front posturing and piloerection.

The adult male was seldom observed at the nest during the nesting period, and then only for food transfers which occurred primarily at the nest. Only the female participated in brooding, sentinel-perching and feeding of the young. Her involvement in these activities subsided by the time the nestlings were three weeks old. By that time nestlings were more ambulatory and more proficient at self-feeding. Other nestling maintenance behavior increased from the second week with continued feather growth and locomotory development and coordination. Ambulatory and social development began in the nest and continued for several days after fledging, as the young hawks spent considerable time on the ground in the vicinity of the nest.

ASPECTS OF THE NUTRITIONAL ECOLOGY OF THE RED-SHOULDERED HAWK (*Buteo lineatus lineatus*) IN SOUTHWESTERN QUEBEC.

Red-shouldered Hawks were studied for two seasons to determine the diet composition and to measure the effect of brood size on the feeding frequency by the parents. Some aspects of their growth were quantified and the effect of specific body parameters and forms of nest attendance were studied.

Adults brought a wide variety of prey items to the nestlings with significantly more mammal prey delivered in 1980 than in 1979. This annual variation of the two main prey types may be related to winter weather conditions prior to each nesting season. The total weight of prey delivered in the 4-hour observation blocks was negatively correlated with the number of prey deliveries in small (1 or 2 young) and large (3 or 4 young) broods. Larger broods received significantly more prey than smaller broods. However individuals of the largest natural brood size (4 young) were not fed as much as individuals of the most common brood size (3 young).

The growth of bill, tarsus and tail feather length were significantly different in broods of 3 compared to broods of 1. No difference was found for wing feather growth or weight gain between the two brood sizes.

Nest attendance in terms of frequency of brooding and delivery of greenery to the nest, was greater in broods of 3 compared to broods of 1.

A combination of increased brooding, delivery of greenery and prey in broods of 3 compared to broods of 1, probably accounted for the differences in growth of certain body parameters.

Penak, Brenda L., 1982. Aspects of the Nutritional Ecology of the Red-shouldered Hawk (*Buteo lineatus lineatus*) in Southwestern Quebec. MSc. Thesis, Macdonald College of McGill University, Ste.-Anne-de-Bellevue, Quebec.

ANNOUNCEMENTS

BURROWING OWL COLORMARKING: REQUEST FOR INFORMATION

In 1983 burrowing owls were colormarked in south-central Saskatchewan during a research program investigating movements of these owls during the breeding season. Information is requested from anyone seeing a colormarked owl to aid in determining migration routes and wintering areas which are presently unknown. Each owl carries a Fish and Wildlife band and from one to three colored plastic leg jesses. Jess colors and yellow, fluorescent red, light blue and dark green and are one centimeter wide and extend approximately 1.5 cm beyond the leg.

Persons observing colormarked owls please record the following: location, date, color and position of leg jess or jesses, leg of attachment of metal band and jess or jesses and any details of the owl's situation. Please send this information to, Bird Banding Office, Canadian Wildlife Service, Ottawa, Ontario, Canada, K1A 0E7 plus an additional copy to the bander, Elizabeth A. Haug, Dept. of Veterinary Anatomy, University of Saskatchewan, Saskatoon, Saskatchewan, Canada S7N 0W0. Thank you for your assistance.

Note: Owls were banded with colored leg *jesses* in Saskatchewan and with colored leg *bands* in Manitoba. Please note this difference if marked birds are seen.

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